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Prescribed Burning for Moose Habitat Improvements

Chugach National Forest

PRESCRIBED BURNING FOR MOOSE HABITAT IMPROVEMENT ON THE CHUGACH NATIONAL FOREST, ALASKA

1987 Progress Report

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ABSTRACT

From 1976 to 1986, 28 sites including 8,150 acres of moose (Alces alces gigas) winter range on the Chugach National Forest have been treated with prescribed fire. This is part of an ongoing project to increase the quantity and quality of hardwood browse available to moose on winter range where current browse productivity is low. Twelve burn sites were evaluated before and after burning to determine: 1) changes in browse productivity due to burning; 2) moose utilization of forage on burned sites during winter; 3) changes in nutritive quality of browse forage due to burning; and 4) changes in moose carrying capacity due to burning. Results indicate browse productivity increased four-fold, from 9 lbs. per acre to 37 lbs. per acre 3 years after burning on average for the 12 sites. Moose are being drawn into and use the burned sites heavily during winter, consuming 44 percent of available browse. Increases in browse nutritive quality were short term, lasting 1 year. Moose carrying capacity increases because of burning are estimated at 115 moose for 8,150 acres treated.

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MOOSE-FIRE MANAGEMENT PROGRAM
CHUGACH NATIONAL FOREST, ALASKA

INTRODUCTION

In the sequence of forest succession on the Kenai Peninsula in southcentral Alaska, hardwood stands (birch, willow, and aspen)[1] are replaced by spruce and hemlock over time if the normal cycle is not interrupted by insects, disease, or fire. Historically, natural and human-caused fires have often interrupted this succession, thereby creating more hardwood stands because these species sprout and grow following fire. The young branch tips of these hardwoods are preferred by moose for browsing, especially in winter.

With more extensive fire control on the Kenai in recent years, more hardwood stands have become spruce and hemlock forest with little browse in them for moose. In maturing hardwood stands, birch, willow, and aspen are growing too tall for moose to reach. With this loss of young birch-willow-aspen habitat in their wintering areas, moose numbers have declined steadily. In an effort to restore more moose habitat to the Kenai, the Chugach National Forest initiated a moose habitat improvement program in 1977.

The program uses prescribed fire to establish more moose habitat. Prescribed fires are those ignited, held, and extinguished under carefully controlled conditions for specific objectives. An environmental impact statement, written in 1977 on the program and circulated for public comment, identified 139 areas including 22,000 acres to be treated with prescribed fire. The objective of the program is to increase the quantity, quality, and availability of moose browse on important winter range.

Objectives

The objective of this report is to evaluate the effectiveness of the prescribed burning program on the Kenai Peninsula. Since the initiation of the program in 1977, 8,150 acres of winter range have been treated with varying degrees of success. Specific objectives of this report are to determine: 1) changes in browse production following fire; 2) moose utilization of burned areas; 3) changes in browse quality following fire; 4) changes in moose carrying capacity due to burning; and 5) if objectives of the original proposal are being met.

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[1]Scientific names for plant species are listed in Appendix B.

BACKGROUND

Declining moose population

Alaska Department of Fish and Game aerial surveys indicate that the moose population on the Kenai Peninsula portion of the Forest is at an all time low since surveys were begun in 1962. Before 1962, little was known about moose population fluctuations on the Forest. Severe winter conditions in 1971 and 1972 resulted in the loss of high numbers of moose calves. A 1971 Fish and Game estimate had calf losses as high as 80 to 95 percent. Losses from early winter through spring continued to be high until 1975. From the 1977 count, it was confirmed that the population had declined to an all time recorded low. Wildlife biologists suggests that a high rate of predation and winter range deterioration are primary causes of this herd's decline.

It is often said that moose populations on the Kenai are declining because of the impact of predation, hunting, or deteriorating habitat conditions. The effects of predation and hunting are fairly obvious, well recognized by the public, and have been the subject of controversy. Changing habitat conditions and their effects on moose populations are much more difficult to assess and understand, but are no less important to moose welfare. For a species like the moose, the element of habitat that is in short supply is food--especially, on winter ranges.

Inadequate range becomes most critical during the winter, affecting primarily the production and survival of calves. Calves are the segment of the population most susceptible to winter losses. In addition, cows debilitated by poor nutrition in winter may give birth to weakened calves; these calves are highly vulnerable to predators and other mortality factors.

Land use practices on the Forest also contribute to the decline in the moose population. Fire control has effectively reduced the frequency and extent of burning of lowland forested areas and old browse ranges. Traditionally, fires returned these areas to productive moose range. The carrying capacities of existing winter ranges are decreasing as a result of over-utilization of forage species, the growth of browse plants beyond the reach of moose, or replacement of browse species by spruce. Human development is encroaching on once-prime moose winter range. Placing roads in valley bottoms has caused further losses of critical winter range. Roads in critical winter habitat result in a direct loss because of moose and vehicle collisions. Fences, built near habitations, have become barriers to moose migrating from summer to winter ranges. With these encroachments on traditional wintering areas, it is becoming necessary to rejuvenate old ranges or create new ranges to reduce the pressures on existing winter ranges.

Deteriorating moose winter range

In winter, moose feed on the young growth of hardwood plants (birch, willow, and aspen). These species sprout and grow after a fire creating good moose winter forage conditions (early successional stage). The Kenai Peninsula

has a history of large wildfires which have created large areas of moose winter range. Numerous wildfires in the late 1800s and early 1900s burned tens of thousands of acres on the Forest (Lutz 1960), but with improved fire supression, large wildfires have not occurred in these moose winter ranges since those early years. Without fire, these ranges are moving into a late sucesssional stage where hardwood browse species have grown out of reach of moose and are being replaced by spruce.

Reports of moose winter forage problems on the Chugach National Forest date back to 1940. That year Edwards, a U. S. Fish and Wildlife Service biologist, reported that over utilization of preferred winter browse species was commonplace throughout the Forest, and that spruce regeneration was encroaching upon mixed stands and rapidly replacing valuable aspen, birch, and willow species.

Figure 1. White spruce encroachment in a paper birch stand on moose winter range.

In 1962, the USDA Forest Service and Alaska Department of Fish and Game established winter browse transects on the Forest to study the condition of moose winter browse. Readings were made annually until 1972. The conclusion was that winter ranges have deteriorated due to over-utilization and low productivity (Culbertson 1977). These surveys indicated that moose utilization of browse growth approached or exceeded 50 percent of that available. Biologists in the study reported that birch and willow grew out of reach of moose (over 8 feet). This study concluded that if forest succession is allowed to run its course on these wintering areas this downward trend in moose winter forage conditions will continue.

The gradual loss of winter range capable of supporting high moose densities appears to be related to the latest moose decline on the Forest. Moose require early successional habitat for their winter forage. High to moderate moose densities cannot be expected on the Forest unless habitat disturbances regularly occur on wintering areas. Because of their potential reproductive capacity and dispersal patterns, moose characteristically increase when forage is abundant--such as after a fire. In the absence of hunting or natural predation, moose populations in successional habitats decline as forage grows out of reach and the browse composition changes from hardwood to spruce. These later successional stages are reported to be of poor nutritional quality as moose forage (Oldemeyer 1976). Poor range conditions will influence the condition of the moose and could lead to predation or high rates of mortality during times of stress. Hunting and predation by wolves and bears during a natural decline would tend to hasten the process.

The deteriorating condition of moose range on the Kenai is reflected in the poor condition of Kenai moose as measured by personnel from the Alaska Department of Fish and Game. Data collected on Kenai moose in 1977 show that Kenai moose are of poor quality relative to other herds in Alaska (Franzmann 1977). Severe winters such as the one in 1971-72 have resulted in an 80 to 95 percent mortality rate for moose calves. This implies that winter habitat is deteriorating on the Kenai (Hardy 1977). Given the constraint of deteriorating winter range, we can assume that moose mortality caused by severe winters will continue to keep the population at a low density.

Need for moose habitat improvement

Experience has shown that without periodic disturbances moose winter range will continue to decline. Realizing the need to reverse this downward trend in moose winter forage conditions the Chugach Forest began exploring ways to improve moose winter habitat.

Mechanical treatments

Forest efforts aimed at improving moose winter forage conditions began in 1966. During the project bulldozer drawn rollers were used to crush down and break up old spruce forest stands to remove the canopy and allow for sprouting and new

seedling growth of browse species. Advantages of this treatment are its manageability in making different clearing configurations and ability to work near developed sites without fear of damaging them. Two major disadvantages to the mechanical treatment are the expense and it cannot be used on rugged, remote, or non-road accessed terrain. Other disadvantages are that it does not kill young spruce. The spruce tends to re-establish more quickly after crushing than after burning, minerals and nutrients are not recycled as thoroughly or as quickly as with fire, and birch does not grow back into dense stands as it does after fire as shown on a 35-acre test plot (Culbertson 1976). Estimated treatment costs in 1976 were $150 per acre as compared to $20 per acre for burning. The Forest discontinued mechanical treatments based on the results of Culbertson's study and the expense involved.

Herbicide treatment

In 1966, portions of a spruce-hardwood plant community on Quartz Creek were treated with aerial applications of 2-4D, and 2-4-5T herbicide sprays. Three areas were treated with different amounts of herbicide: 1 pound-per-acre (lb/ac), 2 lbs/ac, and 3 lbs/ac. The objective was to test the feasibility of using sprays in rehabiliting moose winter range by increasing the number of hardwood sprouts available for browsing by moose. Culbertson (1975) summarized the results:

1. As conducted in this study, treatments of willow with 2-4D, and 2-4-5T herbicides will produce short-term increases in the number of hardwood sprouts but no significant increases by five growing seasons later.

2. Treatments of birch and aspen with 2-4D, and 2-4-5T herbicides result in neither short or long term increases in browse nor greater availability.

Culbertson went on to conclude that birch is generally the more abundant deciduous tree in the overstory of overgrown browse ranges on the Forest. It appears to be very susceptible to killing by herbicide (80 percent mortality). Conversely, spruce trees are more resistant to this herbicide.

In light of these observations it appears possible that herbicide treatment of such ranges may suppress the hardwoods and give spruce the advantage in competition, thus reducing a range's browse capacity rather than increasing it over the long term. Indeed, on some commercial forest lands in the U.S. such herbicide treatment is used to favor conifer growth over competing hardwoods.

In summary, alternative methods aimed at improving moose winter range on the Forest have been attempted. They have proven to be expensive and not entirely adaptable to the area's rugged terrain and have achieved marginal results. After re-evaluating the crushing and aerial spraying projects and then seeing how effectively prescribed burning was being used to improve big game ranges in the lower forty-eight (Gordon 1976), the Forest decided to test the feasibility of burning by prescription and to evaluate the effectiveness of the fire at producing browse.

STUDY AREA

This study is located on the Chugach National Forest portion of the Kenai Peninsula in southcentral Alaska (Fig. 2). This area, containing approximately 1,200,000 acres, is bounded on the west by the Kenai National Wildlife Refuge, on the east by Prince William Sound, on the south by the Gulf of Alaska, and on the north by Turnagain Arm. Anchorage, the largest population center in the state, lies 50 miles northwest of the Forest boundary.

The area is characterized by rugged mountain terrain interlaced by narrow valleys running north and south. Elevations vary from sea level to about 6,000 feet. The eastern and southwestern boundaries are heavily glaciated and most of the lakes and streams in these areas "carry" heavy silt loads.

Vegetation varies considerably with elevation. Timber stands, both spruce and hardwood, are found in the valley bottoms and extend up to 1,500 feet in elevation. Large willow shrubfields are also found in this elevation range. The steeper slopes of the mountains are generally covered by thick stands of alder in the 1,000 to 2,500-foot range. Above 2,500 feet, grassy alpine meadows dominate the landscape along with barren rock outcroppings. The annual precipitation averages 25 inches in the valley bottoms with much of this occurring in the form of snow in the winter and rain in the spring and fall. The first snowfalls begin in mid-October and the snow cover usually lasts in the valleys until early May. Summer temperatures are moderate and average around 56 degrees Farenheit. Temperatures may occassionally reach into the eighties. Winter temperatures average around 28 degrees with lows reaching minus 20 degrees.

STUDY SITES AND TREATMENTS

Selection of burn sites for evaluation

Table 1 lists burn sites, year of burn, acreage, pretreatments, and vegetation types for the sites evaluated in this report. The 12 sites selected for evaluation represent 56 percent of all acreage burned during the program. Burn sites were selected based on availability of preburn data. Time limitations during the field season have not allowed us to get preburn and postburn data on all sites burned. A cross section of sites is represented so that the response of fire to pretreatment and vegetation types can be analyzed.

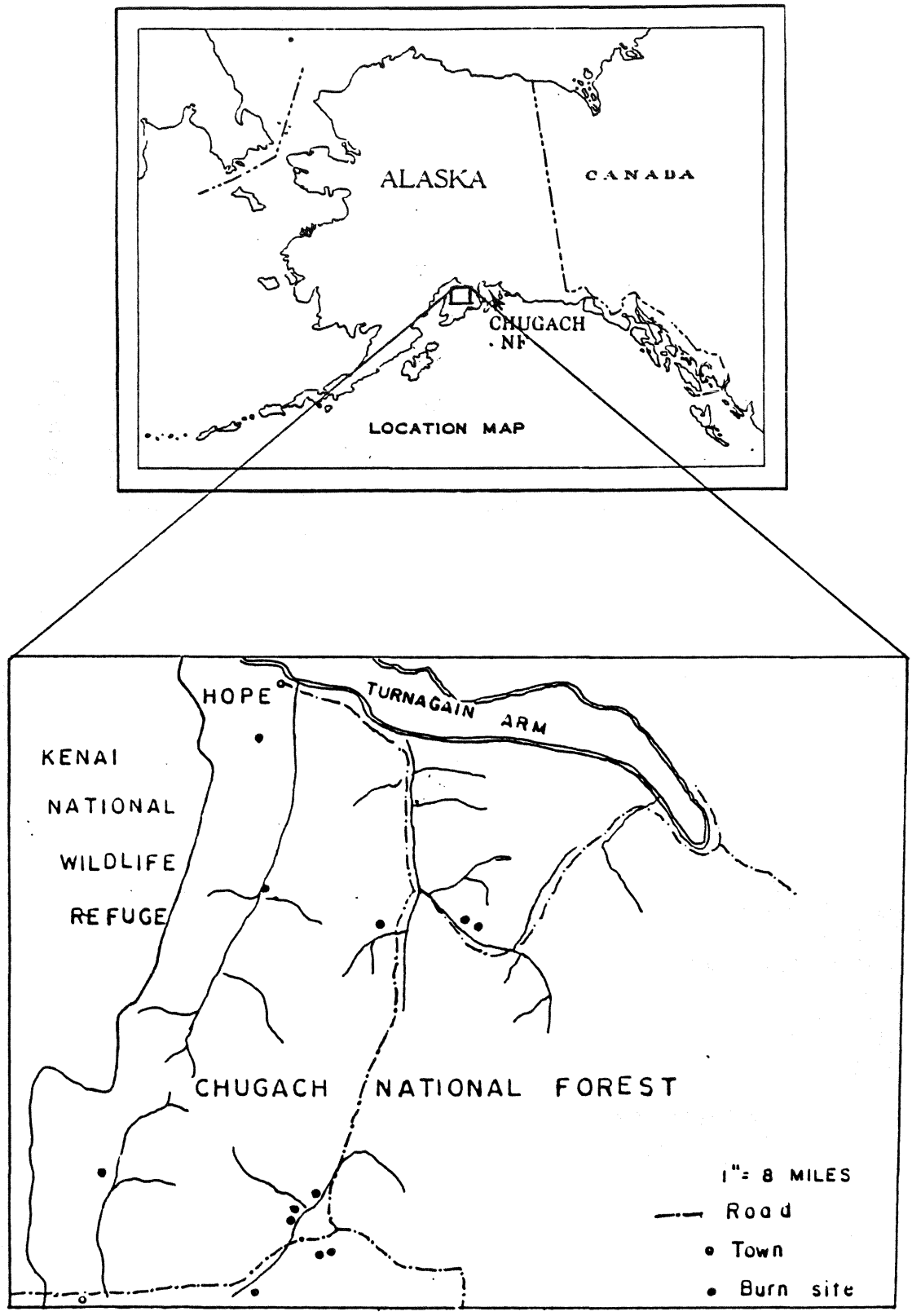

Fig. 2. Location of prescribed burn sites on the Chugach National Forest in southcentral Alaska.

Table 1. List of burn sites evaluated in this report.

Site	Year burned	Size (acres)	Pretreatment	Vegetation type
Dave's Creek	1976	3	slashed	spruce-hardwood
Quartz 13A	78	90	slashed	spruce-hardwood
East Fork 3	79	47	slashed	shrub willow
East Fork 8	79	85	slashed	shrub willow
Quartz 6	79	33	slashed	shrub willow
Quartz 28	81	60	slashed	spruce hardwwod
Quartz 29	81	60	slashed	spruce hardwood
Canyon Cr 5	81	40	none	spruce hardwood
Quartz 34A	81	240	slashed	spruce hardwood
Juneau 1	83	1000	none	spruce hardwood
Caribou Creek	84	2700	none	spruce hardwood
Cripple Creek	84	340	none	spruce hardwood

Pretreatment

Table 1 shows that eight of the sites were pretreated by slashing (felling of all spruce trees) to provide better ground fuel conditions. Slashed sites were cut 2 years before burning, allowing the cut trees to cure. These slashed sites generally resulted in hotter fires because more fuels were available on the ground.

Vegetation type

We burned in two distinct vegetation types: 1) spruce-hardwood, and 2) shrubby willow. The spruce-hardwood type consists of a mix of white spruce, paper birch, Scouler willow, and aspen trees. Important moose browse species in this vegetation type are birch, willow, aspen, and cottonwood. Burning in this forest type results in increased stump sprouting of hardwood browse species and increases in hardwood seedlings. These increases vary depending on the severity of the burn, hotter fires usually result in higher sprouting and seedling regeneration.

The shrub willow vegetation type consists of dense waist-high fields of Barclay's willow. This species is an important winter browse species for moose as identified in surveys in 1983. These willows are very susceptible to fire and are easily top-killed by fire. Generally, grass fires give a hot enough fire to kill the cambium layer of the plant and cause sprouting. Burning in this type kills the above-ground portion of the willows resulting in a dense growth of stems around the base of the plant 1 to 2 years after burning.

METHODS

Burning seasons

All burns from 1976 to 1986 were spring burns conducted in May and June. Controlled burning is most feasible in early spring after the snow melts at the lower elevations. Weather varies somewhat from year to year, but there will usually be only 10 to 20 days when fuel moisture and humidity are such that a burn will be successful. Sites are ready for burning when the snowline recedes and dead herbaceous fuels are adequately dried. Burning operations are usually terminated by the middle of June because of vegetation "greenup". New growth of grass shoots at this time results in live fuel moistures that are too high to "carry" a fire.

The Forest is planning to experiment with burning from September to November during 1988. Conducting these fall burns will depend on the first killing frost or natural curing of grasses. An advantage to burning during the fall is that the drier litter and duff layers will create hotter fires at ground level. This will result in greater consumption of the the moss and duff layers allowing for improved hardwood seedling growing conditions. A disadvantage is the rainy weather at this time of year.

Fuels

Two carrier fuels, cured grasses and spruce slash, were used. Cured grass from the previous year was the main fuel on nonslash sites where trees were not slashed before the burn (Fig. 4). Spruce slash was the main fuel on sites where spruce trees were slashed 2 years before burning (Fig. 3).

Burning prescription

Important factors in the burn prescription are: 10 hour time lag dead fuels, relative humidity, wind direction and velocity, temperature, and live fuel moistures (where applicable). By carefully monitoring weather conditions on the sites during the fire, we found that burning could be done within the ranges shown on the following chart:

WEATHER PRESCRIPTION		
MINIMUM	OPTIMUM	MAXIMUM
20% R.H.[1] wind 0 m.p.h. 9% - 10-hr. fuel[2]	35-40% R.H. wind 5 m.p.h. 12% - 10-hr. fuel	50 % R.H. wind 8 m.p.h. 14-15% - 10-hr.fuel

[1]R.H. = relative humidity
[2]10 hr. fuel = 10 hour time lag fuel moisture

Figure 3. Prescribed burning in spruce-hardwood slash provided for high fuel loadings and high fire intensity.

Figure 4. Burning in spruce-hardwood with no slash. Grasses and downed snags were the main fire carriers in this type.

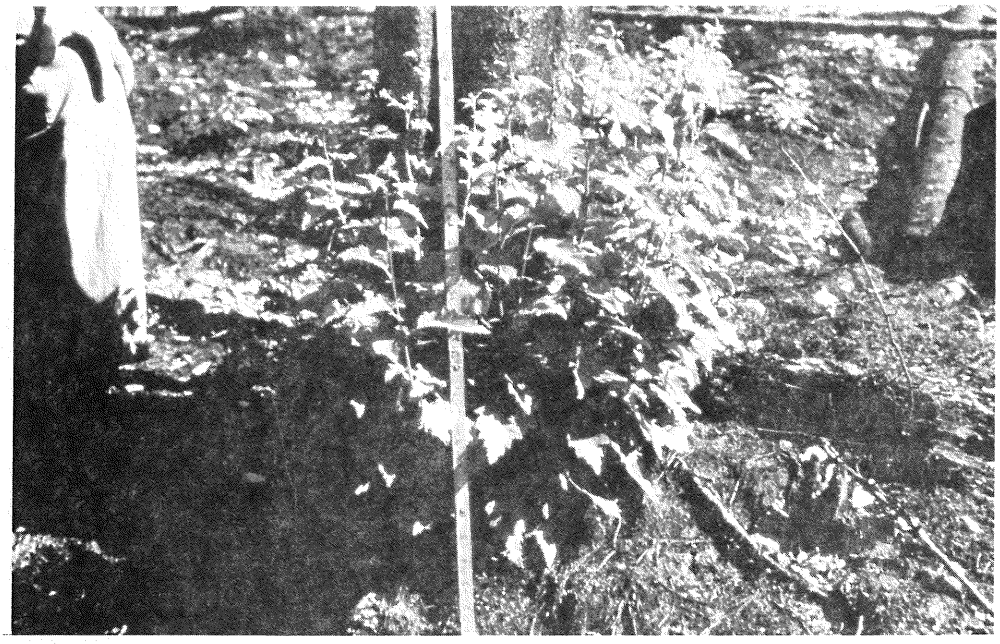

Figure 5. Sprouts growing from the base of a paper birch three months after burning. Birch is an important winter browse species for moose. Burning provides winter forage for moose by stimulating sprouting from the trunks of hardwood tree species.

Figure. 6. Sprouts growing from the base of a Scouler willow three months after burning. This species provides important winter browse for moose.

There is an optimum range for burning, but it depends on topographic features, position on the slope, aspect, and fuel loadings. As a general optimum, 12 percent dead fuel moistures, 5-mph wind speeds, and 35 to 40 relative humidities were found to be better for control and achieving desired results.

Burn ignition

In the first years of the moose habitat improvement program using prescribed fire, burns were ignited by ground crews using hand held diesel "drip" torches. This procedure was time-consuming and presented safety hazards because people were required to climb over downed timber to ignite the fire. Since ignition was slow, precise control over the fire was difficult to obtain.

In the spring of 1981, the Chugach National Forest began using a relatively new ignition device called a helitorch. The helitorch, suspended 20 feet beneath a helicopter, consists of a 55-gallon drum of fuel, igniter, and electric pump, all mounted on an aluminum frame. The entire system, including the fuel, weighs about 650 pounds.

One of the major advantages of the helitorch is it enables fire crews to control the fire much more easily. Weather variables such as wind, temperature, and humidity must be just right for a prescribed fire to begin. Since these factors are all acceptable for relatively short periods, the speed of fire ignition becomes important. The helitorch not only ignites the prescribed fire much faster than ground crews, but it can also shape the burn exactly as desired and create proper wind draft needed for efficient burning.

Cost savings using the helitorch are becoming significant. Burning costs using hand drip torches on the Quartz 34A unit in 1981 were $33 per acre. With the helitorch, costs could have been reduced to $18 per acre. As the use of the helitorch becomes more refined and larger units are burned, costs have gone down to $20 per acre.

Use of the helitorch, together with natural firebreaks has enabled us to treat larger areas and reduce the time and cost required to complete a burn. This shortened firing time is extremely critical when the "window" in which a burn can be successfuly ignited is limited to the afternoon periods of the day. When firing an area, safety strips are first burned out adjacent to the upper most fire line. Ignition then proceeds with the helicopter making passes along the contour across the area, working downwards at intervals until the area is totally burned. After the burn, mop-up crews walk the perimeter to make sure the fire is totally out.

Fire effects inventories

One transect line is placed in each distinct vegetation type within each burn unit to inventory fire effects. Pre and postfire measurements are taken on the same plots.

Fuel inventory

Downed woody fuels are inventoried to determine if sufficient fuels exist on the site to "carry" a fire hot enough to stimulate browse growth (sufficient fuel loadings for burning are given in Appendix 3). [1]Downed woody fuels are inventoried using 10 sampling points on a 1,000 foot[1] transect line. At each point, the planar transect method (Brown 1974) is used to determine fuel loading in tons per acre. Measurements taken on this survey are:

1. fuel loading (tons per acre)
2. depth of fuel
3. percent tree kill
4. percent area burned
5. scorch height on trees
6. duff depth

Browse production inventory

An important part in evaluating the success of a prescribed burn is comparing the quantity of browse food available to moose before and after the burn. This quantity of browse food available is measured as the number of food plants or stems per acre or as the pounds of food production per acre.

Moose browse on the low growing forms of hardwood species such as stems from shrubs, seedlings, saplings, and sprouts from the bases of trees. We designed our sampling scheme to measure browse production from these growth forms. These surveys are done in August when plants have reached their maximum growth for that year. A permanent[2] transect line is established in each distinct vegetation type on the site[2]. Twenty sampling points are located on a 1,000 ft. line with sampling points at 50 ft. intervals. At each sampling point, a 3.2 by 16 foot (1 by 5 meter) plot is laid out on the ground and all stems from shrubs and seedlings are counted within the plot for all moose browse species. From this data are calculated the number of browse stems per acre for shrubs and seedlings.

Next, the area around the sampling point is divided into four quarters (point-center-quarter method) and the nearest sapling and tree in each quarter is located for each browse species. The distance to each sapling and tree is measured and recorded. Sprouts around the tree are counted and their heights are measured. From these data we calculate the number of sapling and tree sprouts per acre for all browse species.

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[1]All measurements given in this report are in English units. Conversions to metric units are given in Appendix A.

[2]Permanent transect lines were started in 1981. Transects surveyed before 1981 within a site were kept in the same general area of the site.

In order to determine browse production as pounds per acre, we need to find an estimate for the weight of new growth produced on each food plant stem. In the field, 20 randomly located food plants of each species are clipped of all the current year's growth. The current year's growth is clipped because moose eat mostly the nutritious new growth from plants. The leaves are removed because the leaves will not be available as food to the moose during winter. The bare twigs are oven-dried for 24 hours and weighed to give the dry weight per plant stem. Dry weight per stem is then multiplied by stems per acre to arrive at pounds of production per acre:

WEIGHT PER BROWSE STEM x BROWSE STEMS PER ACRE = BROWSE PRODUCTION PER ACRE

These browse inventories are done before and at 3-year intervals after a prescribed burn to determine changes in browse production because of burning.

Moose utilization survey

In 1983, the Forest designed a survey to determine how many moose use the burned areas versus the adjacent nonburned areas in winter. Five burn sites were surveyed, using the same permanent plots established for the browse production surveys. In addition, control plots were established in adjacent unburned areas that were similar in vegetation and topography to provide a means of comparison.

The Shafer (1965) twig-count method was used to estimate the weight of browse consumed by moose on burned areas and adjacent controls. In May 1984, the total numbers of browsed and unbrowsed twigs were counted on 40 to 100 stems of each species in the burn and control. Only current annual growth twigs were included. The diameter at the point of browsing was measured on 50 browsed twigs of each species. Fifty unbrowsed twigs of the same diameter were clipped, oven dried and weighed in order to determine the mean weight per twig. The mean weight per twig was then multiplied by the number of twigs available per stem to get the mean weight of browse available per stem. An estimate of the browse consumed per acre was obtained by multiplying the total browse available by the percentage of browsed twigs. Dividing the total browse consumed per acre by the amount moose eat per winter (about 1,980 pounds) will tell us the number of moose using the area per winter.

WEIGHT OF BROWSE AVAILABLE x PERCENTAGE BROWSED TWIGS = BROWSE CONSUMED

WEIGHT CONSUMED ÷ CONSUMPTION RATE PER MOOSE = NUMBER OF MOOSE

Pellet group counts were made to determine how much moose activity occurred in the burned areas versus unburned areas. Pellet group counts were made in ten 500-ft^2 rectangular plots in the burn and adjacent control. These counts were made in the spring so only winter pellets were counted, i.e. pellets which were still brown and not turning white or gray.

RESULTS AND DISCUSSION

Fire effects surveys

Table 2 summarizes results from the fire effects surveys for the 12 sites evaluated in this report. Fuel loading was the main factor in determining these results. Slashing increased fuel loading three-fold, resulting in more surface burn, higher fuel consumption, higher percent tree kill, and more duff removed. Overall, 68 percent of the surface area was burned on the sites. This mosaic pattern of burning is beneficial to moose because it preserves important islands of hiding and thermal cover. The percentage of trees killed varied greatly (Appendix 4). Slash burns resulted in a tree kill of 75 percent, compared to only 31 percent on nonslash burns. Percent tree kill was less than 10 percent on 3 of the 4 nonslash sites. Percentage of duff removed was generally low, a loss of 13 percent on slash burns, and 6 percent on nonslash burns.

Table 2. Results of fire effects surveys for the 12 sites identified in this report.

Pretreatment	Fuel loading[a]	Percent surface burn	Percent fuel consumption	Percent tree kill	Percent duff removed
Slash (n=8)[b]	4.3	72	60	75	13
Nonslash (n=4)	1.6	64	38	31	6
Average (n=12)	3.0	68	49	53	8

[a]Fuel loading in tons per acre for 0 in. to 3 in. diameter downed woody fuels.
[b]The n=number of sites surveyed.

These results indicate that lower fire intensities can be expected from future burns where no slashing is done before burning. Because of manpower losses and high costs, slashing is not planned on future burn sites. Preburn surveys will become more important in determining if adequate fuels exist on the site for burning. Flash fuels (dried grasses) and ground litter will be depended on to "carry" the fire. Sites which have standing dead beetle-killed trees will have high fire intensities. Burning on logged-over sites will result in higher fire intensities because of slash scattered over the site.

Browse production surveys

Browse production increased four-fold on burn sites 3 years after burning (Fig. 7) from an average of 9 lbs. per acre to 37 lbs. per acre for all sites surveyed. Production on slash burns was significantly higher than nonslash burn production for for 1 and 3 years after burning (Table 3). Figure 8 shows that production on slash burn sites continued to increase 6 years after burning. No data exists yet for nonslash burn production for 6 years after fire. Future surveys are needed on nonslash burns to determine trends in browse production. Figure 8 shows that browse production in the shrub-willow type reaches a peak about 6 years after burning and then declines. Production in the spruce-hardwood slash sites is expected to peak at about 15 years after burning.

Table 3. Comparing browse production before and after burning for all sites surveyed in this report.

Pretreatment	Preburn (lbs./acre)	Postfire time (years) 1	3
Slash burns (n=8)[a]	13.8 A[b]	17.4 B	63.2 C
Nonslash burns (n=4)	4.2 A	9.4 A	11.6 A
Average (n=12)	9.0 A	13.4 B	37.4 C

[a]The n= number of sites surveyed.
[b]Numbers followed by different letters are statistically different ($p<0.05$).

These results show that higher fire intensities generated by slash burning resulted in higher amounts of browse production after fire. This results in greater litter and duff removal allowing for more hardwood seedlings to grow on the site. A high percentage of trees killed on slash sites opens up the canopy and allows for increased penetration of sunlight and more favorable browse seedling conditions.

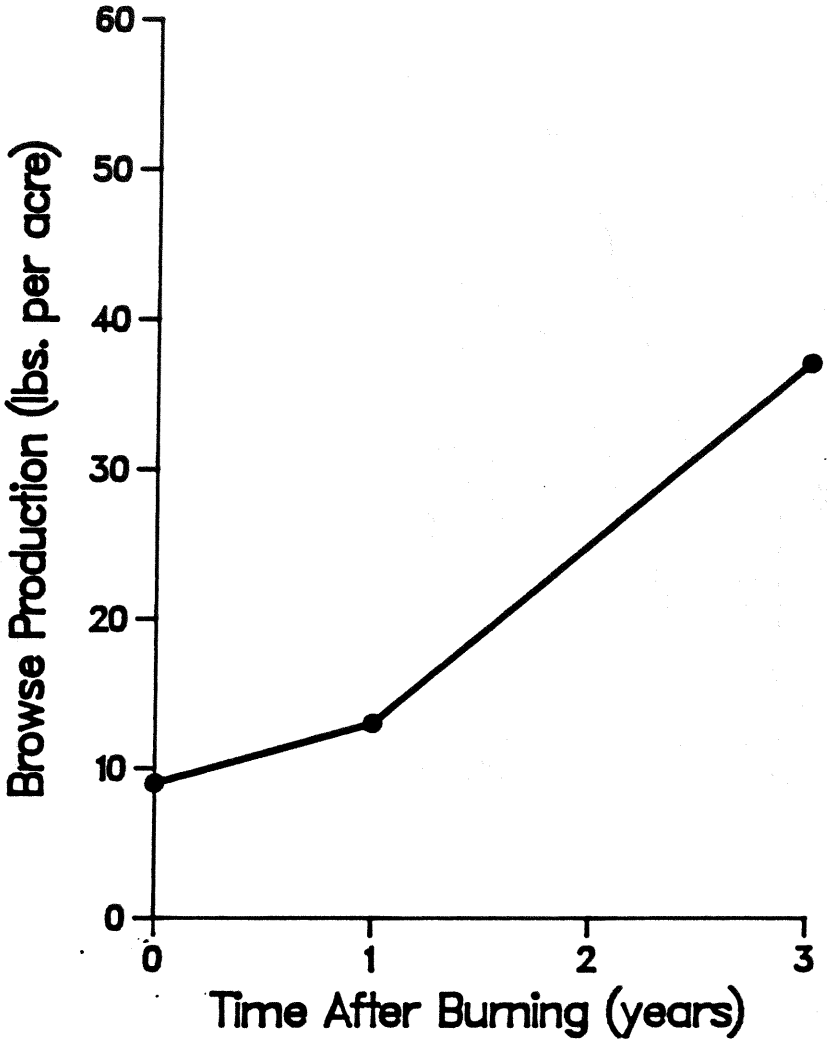

Fig. 7. Average moose browse production after prescribed burning for all sites surveyed.

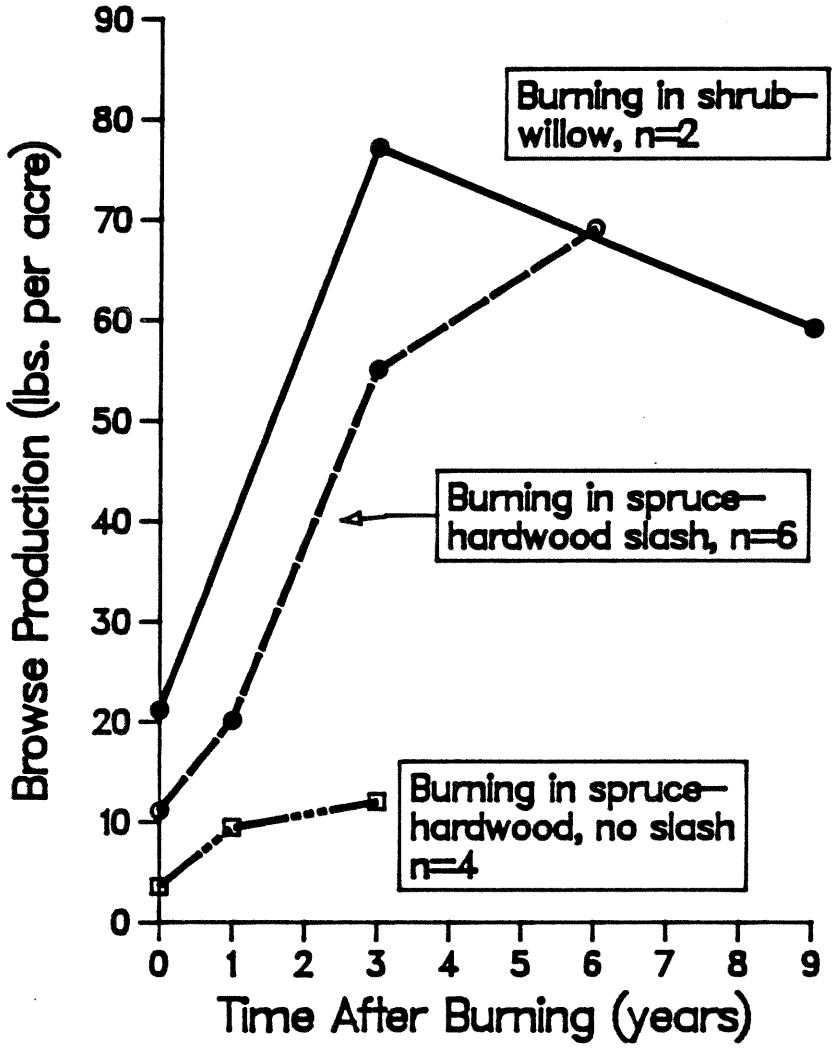

Fig. 8. Comparing moose browse production after prescribed burning for different fuel types (n= number of sites).

Table 3 provides estimates of the level of browse production that can be expected in the future when no pretreatment is done on the site. Browse production increased three-fold on these sites 3 years after burning with most of this production coming from sprouting at the bases of fire-damaged hardwood trees. Browse seedling production is generally low and spotty because fire intensities are not high enough to create good seedling growth. Percent tree kill is generally under 10 percent when beetle killed trees are not present. These burns will mean shorter term benefits to moose because the overall composition of the stand does not change and spruce encroachment and shading by spruce will continue. In addition, lower fire intensities sometimes stimulates grasses already on the site to sprout resulting in heavy grass cover which slows down hardwood seedling regrowth. These fire intensities are sufficiently hot to stimulate grass rhizomes to sprout, but not hot enough at ground level to kill existing rhizomes. Hardwood seedlings are able to grow through grass over time however if the duff layer is not too thick. This is happening on the Caribou Creek site. A way to suppress grass cover is to increase fire intensity at the ground level. This is likely to occur in fall burning. Studies elsewhere have shown a reduction in grass cover from fall burning (Gruell et al 1986). Higher fire intensities on nonslash sites such as beetle-kill sites and logged-over sites will improve seedling growing conditions allowing for increased production. Burning in shrub-willow sites caused increased sprouting of these shrubs resulting in increased browse production at least nine years postfire (Fig. 8).

Estimating increases in moose carrying capacity due to burning

Although several factors combine to influence carrying capacity, browse production figures can be useful in estimating the potential carrying capacity. Estimates of carrying capacity based on browse production alone are not accurate population predictors, but can be used to compare the capability of different sites to support moose. Table 4 compares maximum potential carrying capacity before and after burning on prescribed burn sites.

Carrying capacity for one winter is calculated by dividing the total amount of browse available by the winter consumption rate for one moose. The winter consumption rate is 11 lbs. per day of browse for a period of 180 days (V. Van Ballenberghe, U.S. Forest Service, pers. comm.) or 1,980 lbs. Using 37 lbs. as the average weight of browse available per acre (from Table 3) on the 8,150 acres treated up to 1986, gives 301,550 lbs. of browse available on all acres treated. This figure divided by 1,980 lbs per moose per winter gives a maximum carrying capacity of 152 moose per winter, a five-fold increase over the estimates for preburn carrying capacity.

TOTAL AMOUNT OF BROWSE AVAILABLE	÷	MOOSE CONSUMPTION PER WINTER	=	MAXIMUM POTENTIAL CARRYING CAPACITY

The figure of 37 lbs. per acre should increase as more hardwood seedlings grow on the burn sites. Hardwood browse production generally peaks 15 years after fire (Spencer and Chatelain 1953).

Table 4. Estimates of potential winter carrying capacity of burned sites.[1]

Area treated	No. Moose before burning	No. Moose after burning	difference
For 8,150 acres	37	152	115
For 12,250 acres[2]	68	280	229

[1]Carrying capacity is defined as the number of moose that a given area can support for one winter. Based on a daily consumption rate of 11 lbs. dry weight per day per moose for 180 days.

[2]Projected acreage burned during the period 1976-94.

Moose utilization surveys

Results from the browse utilization surveys are summarized in Table 5. Moose browsed 44 percent of new hardwood growth on burn sites and 35 percent on control sites for the five sites surveyed. These figures represent utilization for the winter of 1983-84. This winter was considered a fairly average winter, however, future surveys are needed to determine if these figures represent average use. Severe winters are expected to result in higher browsing by moose with less browsing during mild winters.

Table 5 shows that moose consumed five times more browse in the burn (18 lbs. per acre) than unburned control sites (3.5 lbs. per acre). The data shows that burn sites are producing more browse per acre and that moose are browsing a higher percentage of twigs in the burns (Fig. 9).

Moose use of individual browse species varied greatly. Scouler willow ranked highest in percentage of twigs browsed (50% burn, 45% control) for all sites surveyed. Paper birch and Barclay willow were browsed moderately, receiving heavier use in the burns. Aspen and black cottonwood were browsed lightly (<10%) both in the burns and controls.

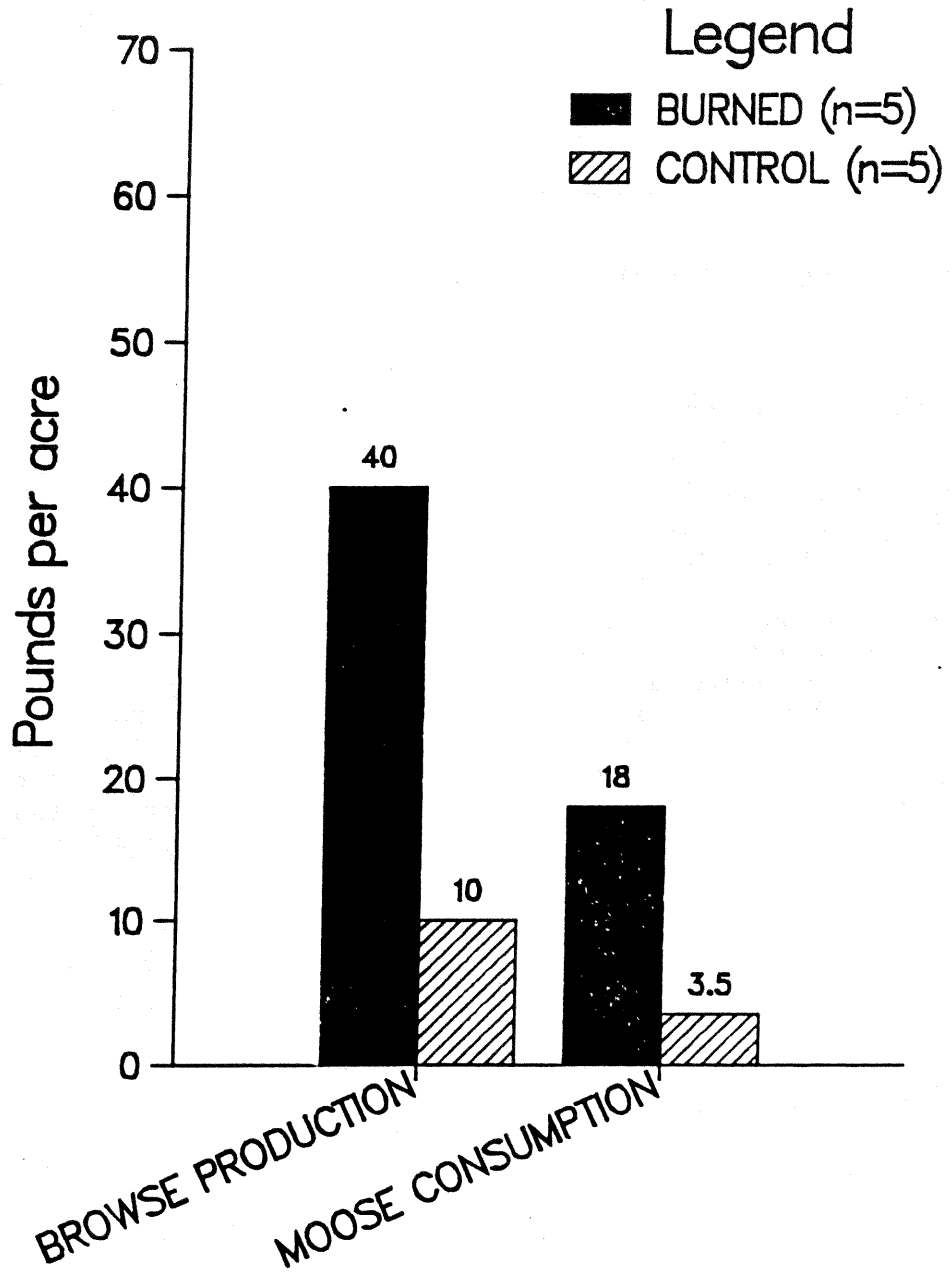

Fig. 9. Comparing browse production and winter consumption by moose on prescribed burn sites and unburned (control) sites, n= number of sites.

Table 5. Comparison of browse production and utilization by moose on prescribed burn sites and control sites for the winter of 1983-84.

Pretreatment	Browse produced lbs./acre		Browse consumed lbs./acre		Browse consumed percent	
	burn	control	burn	control	burn	control
Slash burns (n=3)[a]	63	12	26	4	41	33
Nonslash burns (n=2)	17	8	10	3	47	38
Average (n=5)	40	10	18	3.5	44	35

[a]The n=number of burns surveyed.

Numbers of moose using burn sites

The results of the browse utilization surveys can provide estimates of the number of moose using the burn sites and adjacent unburned control sites for a winter. Table 5 compares numbers of moose using the burned sites to numbers of moose using the adjacent control areas.

The number of moose using the area for one winter is calculated by dividing the total amount consumed by the winter consumption rate for one moose. Using 18 lbs. per acre as the amount of browse consumed on burned sites (Table 5) gives 146,700 lbs. consumed on all sites (18 lbs./acre x 8,160 acres). This figure divided by 1,980 lbs. (winter consumption rate for one moose) gives 74 moose using the burned sites, a five-fold increase over the estimate for the adjacent unburned control sites (Table 6). The number of moose using the same burned acreage was estimated at 72 moose by using pellet group counts (see Appendix 7).

TOTAL AMOUNT BROWSE CONSUMED ÷ MOOSE CONSUMPTION PER WINTER = NUMBER OF MOOSE DURING WINTER

Table 6. Estimates of the number of moose using burned sites and adjacent control sites for one winter.

	Number of moose		
Area treated	control	burn	difference
For 8,150 acres	14	74	60
For 12,250 acres[1]	22	111	89

[1]Projected acreage burned during the period 1976-94.

Nutritional quality of moose browse following burning

An objective of the Chugach Moose Habitat Improvement Program is to increase the nutritional quality of moose browse through burning. Past studies elsewhere (Ahlgren 1965, Ahlgren 1970, and Overrein 1967) have indicated that burning helps browse growth by releasing mineral nutrients that have accumulated in dead plant material. Burning is known to speed up nutrient cycling in the system by removing insulating organic layers (moss and duff) from cold northern soils. This allows for increased activity of microbial decomposers releasing nutrients (primarily nitrogen) to plants which would otherwise be tied up in the soil. Burning also causes woody plants to produce rapidly growing juvenile shoots as opposed to more slowly growing mature forms in undisturbed habitats.

We measured browse nutritive quality on seven burned sites (five prescribed burns plus two wildfire sites). Adjacent to each burned site we tested plants from an unburned area for comparison purposes. Six browse species were sampled: Barclay willow, Scouler willow, aspen, black cottonwood, paper birch, and lowbush cranberry. Ages of burns ranged from 1 to 24 years. We collected plants in summer and late winter, however, our first interest was in the late winter plants because this represents the time when moose are stressed for food.

Features analyzed in the laboratory included: protein content (nitrogen fraction), moose digestibility (IVDMD), nonstructural carbohydrates (TNC), crude fiber (ADF), and the elements N, K, Ca, Mg, Cu, Zn, and Fe[1]. Moose digestibility was tested by digesting browse twigs in rumen fluids from a free-roaming moose which had been killed on the highway.

Results indicate that nutritional effects from burning were significant for only 1 year. Burning significantly increased protein content, N, P, Mn, Zn, and crude fiber (ADF) and decreased Ca, nonstructural carbohydrates (TNC), and digestibility (IVDMD) (Appendix 6). Individual species responses indicated all

[1]Plants were analyzed at the University of Alaska Agricultural Experiment Station in Palmer, AK, by Dr. J. McKendrick.

plants did not respond alike to burning. For example, paper birch and aspen increased in digestibility following burning. Certain non-significant, but consistent trends among species indicated that with burning Mg, K, Fe, and Cu generally declined while P and Zn usually increased. The fiber fractions, (ADF), cellulose, and lignin generally increased, and digestibility usually declined.

In the among-species comparisons, aspen and black cottonwood out ranked all others in digestibility. Paper birch, Scouler willow, and lowbush cranberry had the lowest digestibiities. Lowest N (crude protein) was found in lowbush cranberry stems even though this is an evergreen shrub and would be expected to maintain acceptable nutritional quality during winter. This plant outranked all species in Mn levels, averaging 1,000 ppm, 30 times the level of the lowest species, black cottonwood.

SUMMARY AND CONCLUSIONS

The results of these studies indicate that burning has significantly increased browse production on the sites surveyed; 3 years after fire, the overall increase has been four-fold. Moose browse consumption surveys indicate that moose are being drawn into and use these burn areas heavily during the winter months. Adequate fire intensities were generated by slash burns which created very favorable hardwood seedling and sprouting conditions. These burns will improve browse conditions for up to 25 years. Nonslash burns have resulted in lower fire intensities and patchier burns with widely varying amounts of browse production, but have stimulated hardwood tree sprouting and marginal seedling establishment. The result of nonslash burning will be shorter term benefit to moose on these sites. This is because tops of trees are not killed by fire, and trunk sprouts that result tend to die back over time if browsed hard by moose. Spruce encroachment and shading will continue to be a problem on these sites. However, in areas near trails and where visuals are a concern, the mosaic pattern created by these burns is more pleasing to the eye.

Resource managers should consider burning in the fall months (September and October) in order to generate hotter fires in spruce-hardwood stands where no slashing will be done. Burning in shrub-willow has increased browse production four-fold by stimulating sprouting. These areas should be burned in spring. Burning in logged-over areas should generate adequate fire intensities to create good hardwood seedling growth because of slash scattered on the site. Browse shrubs and saplings generally do well following logging activities because of the increased sunlight at ground level and decreased competition. Wildlife managers and timber personnel are currently looking at ways to coordinate logging with prescribed burning to produce more moose habitat.

Summary of conclusions

1. Browse production increased from 9 lbs. per acre to 37 lbs. per acre 3 years after burning on the average for all 12 sites surveyed.

2. Burning in slash resulted in significantly higher browse production for 1 and 3 years after fire compared to nonslash burning.

3. Browse production on slash burns increased significantly for 1, 3, and 6 years after burning.

4. Moose have utilized 44 percent of the hardwood browse growth on burn sites during winter, and 35 percent on adjacent control sites for the same winter.

5. Increases in browse nutrient quality as a result of burning were short term, lasting one year.

6. Moose carrying capacity **increases** due to burning (based on browse production figures) are estimated at 115 moose for 8,150 acres burned, and 229 moose for 12,250 acres burned.

7. Numbers of moose using the 8,150 acres treated based on food consumption surveys are estimated at 74 moose per winter on all burned sites and 14 moose per winter on adjacent unburned areas of the same acreage.

Response to original program objectives from 1977

The original objectives for the prescribed burn program in the Environmental Impact Statement (EIS) Chugach Moose-Fire Management Plan were written in 1977 and distributed for public comment. The original objectives and assumptions of the program, together with current status, are given below.

Objective	Current status
Burning of 22,000 acres in ten year period	8,150 acres burned, 12,250 scheduled by 1994.
Increased moose browse production	four-fold increase, from 9 lbs./ac to 37 lbs./ac 3 years after burning
Increase in moose carrying capacity of 2,200 moose for 22,000 acres burned	estimated increase of 229 moose for 12,250 acres burned
Increases in browse quality	short term increase only 1 year increase

Objective	Current status
Increases in browse availability	five-fold increase in browse consumption on burn sites over control sites
Cost: $11.50/acre	cost $20.00/acre
No significant impact on timber resource	unchanged
No significant soil, or water damage	unchanged
Decreased wildfire hazard	improved
No private property threatened by burning	unchanged

Current plans call for burning 12,250 acres by the year 1994. The original goal of 22,000 acres by 1986 has not been met because many of the sites originally scheduled for burning have been omitted because of inadequate fuels to "carry" a sufficiently hot fire. Most of the goals presented in the original project proposal have been met, and the primary objective of improving moose winter range has largely been accomplished. Burning costs have remained above the original target because, on an average, a larger porportion of smaller size sites than originally proposed have been burned. Moose carrying capacity estimates in the original proposal are now considered too high and a more accurate figure based on browse production surveys and moose utilization in the burn sites is given in this report.

Concerns and recommendations

1. Continue burning in spruce-hardwood stands and shrub willow where sufficient fuels and browse exist to warrant burning. The current burning schedule calls for an additional 4,100 acres to be treated from 1988 to 1994.

2. Continue to look at fall burning as a way to generate higher fire intensities at ground level on sites where slashing is not done before the burn. Using the new foam fireline system (W.E.P.S.) may allow us to do more fall burning.

3. Consider reburning sites on a rotating basis starting in 1994. Starting with the older sites would give a 16-year burn rotation. Sufficient fuel buildup should occur during this period to"carry" fire. Prime sites will be Barclay willow shrubfields where browse increases are shorter term.

4. Logged-over sites should be looked at for prescribed burning. These areas should stimulate browse production, especially, if burned in fall when the duff layer has thawed.

5. Areas which are known to be critical moose winter range that cannot be treated with fire may be thinned to promote trunk sprouting. If work crews thin dense stands the birch, willow, and aspen stands should sprout well. These sites could become firewood gathering areas for the general public as well. As much as 25 acres per year could be improved with this program.

6. Continue to do preburn surveys on sites scheduled for burning. Sites selected for continued monitoring at 6-year intervals include: Quartz 13A, Quartz 34A, Quartz 6, East Fork 8, Juneau 1, and Caribou Creek.

APPENDIX A

All data in this paper are presented in English units. Conversion to metric units requires the following constants.

inches x 2.540	= centimeters
feet x 0.305	= meters
acres x 0.405	= hectares
density/ acre x 2.471	= density/hectare
pounds x 0.453	= kilograms

APPENDIX B

Scientific names for plant species given in this paper.

common name	scientific name
white spruce	Picea glauca
hemlock	Tsuga mertensiana
Barclay willow	Salix barclayi
Scouler willow	Salix scouleriana
black cottonwood	Populus balsamifera ssp. trichocarpa
aspen	Populus tremuloides
paper birch	Betula papyrifera
lowbush cranberry	Vaccinium vitis-idaea

APPENDIX C

Fuel loading requirements for burning with probable fire effects and browse regrowth

Fuel loading[1]	Fuel depths	Probable fire effects	Browse regrowth[2]
light 0-2 tons/acre	>4 inches	<10% tree kill high shrub kill 50-70% surface burn	willow sprouting no birch sprouting minimal seedlings no aspen suckering
medium 2-4 tons/acre	>4 inches	10-50% tree kill high shrub kill >70% surface burn	willow sprouting some birch sprouting some seedlings some aspen suckering
heavy >4 tons/acre	>4 inches	>50% tree kill high shrub kill >70% surface burn	willow sprouting birch sprouting seedlings aspen suckering

[1]Fuel loading in tons per acre for 0-3 inch diameter downed woody fuels.
[2]Regrowth for all species on the site for different fuel loadings.

APPENDIX D

Results of fire effects surveys for the 12 sites identified in this report

Site	Slash	Fuel loading[1]	Surface burn (%)	Fuel consumption	Tree kill
Slashed					
Dave's Creek	Medium	2.0	70	65%	58%
Quartz 13A	Heavy	NA	80	NA	80
East Fork 3	Medium	4.0	80	NA	90
East Fork 8	Medium	4.0	80	NA	90
Quartz 6	Medium	3.0	90	60	85
Quartz 28	Medium	4.0	40	57	18
Quartz 29	Heavy	8.0	75	49	75
Quartz 34A	Heavy	5.0	60	69	100
average		4.3	72	60	75
Nonslashed					
Juneau 1	None	0.8	50	30	10
Canyon Creek	None	1.0	45	30	8
Caribou Creek	None	4.3	100	58	100
Cripple Creek	None	0.4	60	35	5
average		1.6	64	38	31
Average		3.0	68	49	53

[1]Fuel loading in tons per acre for 0-3 inch diameter dead and downed woody fuels.

Fire temperature data for different fuel types.[2]

Type of fuel/depth	fuel loading	surface temp.	1 ft.	3 ft.
grass/12in.	0.4 t/a	250°	750°	400°
litter/2in.	0.5 t/a	300°	500°	400°
slash/12in.	2.0 t/a	400°	800°	800°
slash/24in.	4.0 t/a	400°	>1200°	1200°

[2]Weather conditions: light overcast, temperature= 60°F, relative humidity=50%, 10-hr. fuel moisture=13, wind speed=3-5 mph, time=1500 hr.

APPENDIX E

Comparing browse production before and after burning for all sites surveyed

	Preburn (lbs./acre)	Postfire time (years) 1	3
Slash burns			
Dave's Creek	5.5	NA	17.0
Quartz 13A	6.8	14.0	104.0
Quartz 34A	12.0	17.0	118.0
Quartz 29	17.0	35.0	25.0
Quartz 28	6.0	13.0	12.0
Quartz 6	10.0	8.0	75.0
East Fork 3	20.0	NA	73.0
East Fork 8	33.0	NA	82.0
average[1]	13.8^{a}	17.4^{b}	63.2^{c}
Nonslash burns			
Juneau 1	5.1	18.0	10.0
Canyon Creek	11.0	18.0	33.0
Caribou Creek	0.3	0.6	0.13
Cripple Creek	0.5	1.4	3.5
average	4.2^{a}	9.4^{a}	11.6^{a}
Total average	9.0^{a}	13.4^{b}	37.4^{c}

[1]Averages with different superscripted letters are significantly different ($p<.05$)

APPENDIX F

Percent protein, digestibility (IVDMD), crude protein (ADF), and nonstructural carbohydrates (TNC) for burned (b) and unburned (c) moose browse plants for different aged burns. Plants were collected in April 1984.

Burn age	Percent protein		Percent digestibility		Percent crude fiber		nonstructural carbohydrates	
	b	c	b	c	b	c	b	c
1	9.1[a]	7.0	32[a]	43	44[a]	32	11[a]	19
2	8.3	8.0	47	50	30	28	19	22
3	8.0	7.4	50	41	35	38	21	18
4	7.6	8.6	45	NA	37	35	20	22
5	7.4	7.4	41	43	39	36	17	22
14	7.8	8.3	30	32	41	41	12	14
24	8.6	8.0	31	32	41	38	15	12

[a]Significant difference between burn (b) and control (c) ($p<0.05$).

APPENDIX G

Moose pellet groups per acre on burned and unburned (control) sites

Site	Years postburn	Vegetation type	Pellet groups burn	Pellet groups control
Juneau 1	1	spruce-hardwood	5	5
Juneau 5	2	shrub willow	22	5
Quartz 34A	3	spruce-hardwood	26	4
Quartz 6	5	shrub willow	54	13
Quartz 13A	6	spruce-hardwood	22	5
Average			26	6

Estimates of the number of moose using burned sites vs. unburned control sites in winter can be made using moose pellet counts. To calculate the number of moose we divided the estimate for total pellet groups in all acres treated by the defecation rate per winter for one moose. Surveys show an average of 26 pellet groups per acre in the burn sites and six pellet groups per acre in the unburned control sites. The total number of moose pellet groups on the acres treated is 220,050 (26 groups/acre times 8,150 acres). This number divided by the moose defecation rate per winter (3,060[1]) gives 72 moose, a four-fold increase over estimates for adjacent control areas of the same acreage (see table below).

	Numbers of moose per winter		
Area treated	Control	Burn	difference
8,150 acres	16	72	56
12,250 acres[a]	24	108	84

[a]Projected acreage burned 1976-94.

[1]Moose defecation rate per winter based on a defecation rate of 17 per day per moose (C. Schwartz pers. comm., ADF&G, Soldotna, AK)

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